Displacement, Speed, Velocity, and Acceleration

$\Delta x = x_2 - x_1$ (similarly for Δy, etc.)

$\bar{v}_x = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$ (similarly for $\bar{v}_y$, etc.)

$\bar{s} = \frac{\text{total distance}}{\Delta t}$

$s = \sqrt{v_x^2 + v_y^2}$

$\bar{a} = \frac{\Delta v}{\Delta t}$

Constant Acceleration

$x_f = x_i + v_{ix}\Delta t + \frac{1}{2}a_x \Delta t^2$

$v_{fx} = v_{ix} + a_x \Delta t$

$v_{fx}^2 = v_{ix}^2 + 2a_x(x_f - x_i)$

$x_f = x_i + \frac{1}{2}(v_{ix} + v_{fx})\Delta t$

Projectile Motion

(assumes $+y$ is upwards)

$a_x = 0$

$a_y = -g$

$g = +9.8 \frac{\text{m}}{\text{s}^2}$

$\tan q_0 = \frac{v_{0y}}{v_{0x}}$

$v_{0x} = |v_0| \cos q_0$

$v_{0y} = |v_0| \sin q_0$

$y = y_0 + (x - x_0)\left(\frac{v_{0y}}{v_{0x}}\right) - \frac{g(x - x_0)^2}{2v_{0x}^2}$

or

$y = y_0 + (x - x_0)\tan q_0 - \frac{g(x - x_0)^2}{2(v_0 \cos q_0)^2}$

$R = \frac{v_0^2}{g}\sin(2q_0)$

(destination and source at same height)

Work, Energy, Power

$W_F = F \cdot \Delta x \cdot \cos q$ (note $\cos 180^\circ = -1$)

$\Sigma W = KE_f - KE_i$

$KE = \frac{1}{2}mv^2$

$\bar{P} = \frac{W}{\Delta t} = F \cdot v$

$PE_{2g} = mgy_2$ if $+y$ is upwards

$E = KE + PE_g$

$E_2 = E_1 + W_{1\to 2,\text{all but gravity}}$, so:

$KE_2 + PE_2 = KE_1 + PE_1 + W_{1\to 2,\text{all but gravity}}$

Center of Mass

$x_{CM} = \frac{1}{m_{tot}}\Sigma m_i x_i$

Momentum & Impulse

$\vec{p} = m\vec{v}$

$\Sigma \vec{F} \cdot \Delta t = \Delta \vec{p}$

$\Sigma \vec{F}_x \cdot \Delta t = m(v_{fx} - v_{ix})$

$\vec{p}_f = \vec{p}_i$ if $\Sigma \vec{F} = 0$

$\vec{J} = \Sigma \vec{F} \cdot \Delta t$

1D Elastic Collisions

$v_{1f} = \frac{m_1 - m_2}{m_1 + m_2}v_{1i} + \frac{2m_2}{m_1 + m_2}v_{2i}$

$v_{2f} = \frac{2m_1}{m_1 + m_2}v_{1i} + \frac{m_2 - m_1}{m_1 + m_2}v_{2i}$

Circular Motion & Rotation

$|a_c| = \frac{v^2}{r} = rw^2$ towards the center of the circle

$|a_t| = ra$

$T = \frac{2pr}{v} = \frac{2p}{w} = \frac{1}{f}$ (constant speed)

$s = r\Delta q$ (distance traveled, Δq in radians)

$T = 2p\sqrt{\frac{R^3}{GM}}$ (orbits)

$\Delta q = q_f - q_i$

$w_{\text{average}} = \frac{\Delta q}{\Delta t}$

$a_{\text{average}} = \frac{\Delta w}{\Delta t}$

$v = Rw$ (on a rotating object)

$r_A w_A = r_B w_B$ (gears)

$KE_{\text{rotation}} = \frac{1}{2}Iw^2$

$W = t\Delta q$

$L = Iw$

$L_{particle} = m r_\perp v$

$\Sigma t \Delta t = \Delta L$

Rolling

$N = \frac{L}{2pR}$

$v_{\text{CM}} = Rw$

$a_{\text{CM}} = Ra$

Torque

$\Sigma t = Ia$

$|t| = |R_\perp F|$

$I_{\text{particle}} = mr^2$

$I_{\text{parallel axis}} = I_{CM} + mh^2$

Vectors

$\vec{A} = A_x\hat{x} + A_y\hat{y} + A_z\hat{z}$

$A = |\vec{A}| = \sqrt{A_x^2 + A_y^2 + A_z^2}$

$q = \arctan\left(\frac{A_y}{A_x}\right)$

$A_x = A\cos q$

$A_y = A\sin q$

Forces

Name an object or group of objects !!!!

$\Sigma F_x = ma_x$, $\Sigma F_y = ma_y$

$W = mg$ (down)

$f_{s,\max} = m_s N$

$f_k = m_k N$

Gravity

$F = G\frac{m_1 m_2}{r^2}$

$G = 6.67 \times 10^{-11}\frac{\text{Nm}^2}{\text{kg}^2}$

$T = 2p\sqrt{\frac{R^3}{GM}}$

Constant Angular Acceleration

$q = q_0 + w_0\Delta t + \frac{1}{2}a\Delta t^2$

$w = w_0 + a\Delta t$

$w^2 = w_0^2 + 2a(q - q_0)$

$q - q_0 = \frac{1}{2}(w + w_0)\Delta t$